Enabling factors of manufacturing servitization: Empirical analysis and implications for strategic positioning

Enabling factors of manufacturing servitization: empirical analysis and implications for strategic positioning

Luca Mastrogiacomo[1], Federico Barravecchia[2], Fiorenzo Franceschini[3]

[1]*luca.mastrogiacomo@polito.it* [2]*federico.barravecchia@polito.it* [3]*fiorenzo.franceschini@polito.it*
Politecnico di Torino, DIGEP (Department of Management and Production Engineering),
Corso Duca degli Abruzzi 24, 10129, Torino (Italy)

Abstract

The introduction of advanced technologies and new production paradigms has led an increasing number of manufacturing companies to adopt business models that include an integrated provision of products and services. This process is generally referred to as servitization. This paper addresses two primary research questions: (i) How do the commodity sector, geographical location and company dimension affect the variety of services offered by manufacturing companies? (ii) What is the impact of these structural factors on the type of services offered by manufacturing companies? To address these questions, this paper provides new insights into the understanding of the servitization process. The main elements of originality of this study are: (i) an unprecedented size of the analysed sample, composed of more than 190.000 manufacturing companies; (ii) a quantitative analysis of the effects of the three aforementioned factors on the servitization process and (iii) a definition of a pair of indicators for evaluating and benchmarking the strategic position of manufacturing companies with respect to their service provision.

Keywords: *Servitization*, *Servitization structural factors, Level of servitization, Manufacturing, Product-Service Systems, Product-related services, Strategic positioning.*

1. INTRODUCTION

Smart manufacturing, Advanced Manufacturing, Industry 4.0 and Digital Transformation are just a few of the concepts that in recent years have been defined to describe the current process that is profoundly changing our attitude towards manufacturing companies [**1**–**3**]. This revolution brought new production paradigms, among which the integration of products and services is one of the most relevant [**4**–**6**]. The scientific literature coined the term servitization to describe this process, intended as "the innovation of an organization's capabilities and processes to better create mutual value through a shift from selling product to selling Product-Service Systems (PSS)" [**7**], i.e. integrated offerings of products and services [**8**]

Previous investigations have qualitatively indicated several factors that served as enablers and barriers to the successful adoption of service strategies in manufacturing companies [**9**–**12**]. It has

also previously been observed that manufacturing companies have different strategies in the diversification of their service portfolio [**9**,**13**,**14**].

However, the current understanding of enabling structural factors affecting the servitization process remains essentially qualitative. The purpose of this paper is to address this gap by quantitatively and empirically analysing a selection of structural factors affecting servitization process. The following Research Questions (RQs) are specifically addressed:

RQ1: What is the impact of the structural factors (commodity sector, geographical location, company dimension) on the variety of services offered (i.e. the number of different types of services offered) in manufacturing companies?

RQ2: What is the impact of the structural factors (commodity sector, geographical location, company dimension) on the composition of the service portfolio (i.e. the types of services offered) in manufacturing companies?

The approach herein proposed is based on the processing of secondary data related to a sample of manufacturing companies in order to gather information about their services offerings. Being composed of 190,000 manufacturing companies distributed all over the world, this sample has no precedent in the literature for its size and geographical distribution.

This study presents a significant opportunity to advance the understanding of the servitization process. In detail, three are the main elements of novelty introduced. Firstly, this investigation provides an updated and solid overview of the extent of servitization process, reporting data related to 21 countries, 22 manufacturing sectors and different company dimensions. Secondly, the statistical analysis reveals that three structural factors (commodity sector, company dimension, geographical location) impact on the extent of the servitization process, both in terms of variety of services offered and composition of the service portfolio. Thirdly, this research identifies a pair of indicators to evaluate and benchmark the strategic position of manufacturing companies with respect to their service provision. The results of this study could be of interest to researchers and practitioners who need to: (i) compare the servitization position of different companies with respect to their relevant market; (ii) compare servitization behaviour in different markets; (iii) analyse the servitization of specific commodity sectors so as to support a company in the identification of its optimal strategic positioning.

The paper is structured as follows. Section 2 summarizes the major contributions related to the topic of the paper, also introducing the hypothesis that drove this research. Section 3 details the methodology of analysis. Results presented in Section 4 are then used in Section 5 to suggest the definition of two specific indicators to evaluate the strategic positioning of a company with respect

to a reference set of competitors. The concluding section summarizes the original contributions of the paper, focusing on the benefits, limitations and possible future developments.

2. THEORETICAL BACKGROUND AND HYPOTHESIS FORMULATION

It is reasonable to imagine that the there may be several factors that can affect servitization, including the industrial context (trend, technological innovation trend, degree of competition, regulation, etc.), the internal environment (degree of customer contact, available financial resources, etc.), market and customer (customer requirements, market readiness, customer culture, etc.).

To obtain a solid figure of the phenomenon it is possible to observe and test the significance of the factors on a sufficiently large amount of data. Due to the complexity of the servitization phenomenon and the limited availability of secondary data, this research aims at verifying the significance of a subset of three structural factors: commodity sector, company dimension and geographical location. The study of their significance may be interesting since the existing body of literature is scarce and limited to the analysis of surveys based on samples of a few companies: (i) a company's commodity sector can affect the strategic choice of service provision, also in consideration of the competition and the specificity of the market [**15**–**17**]; (ii) the company dimension can be seen as a proxy for the availability of (economic and personnel) resources that can enable or facilitate the transition to the provision of services [**15**]; (iii) the geographical location can influence the economic context in which a company operates, thus determining different strategic choices of service provision [**15**,**18**,**19**].

2.1 The servitization process

Over the years, different perspectives have been adopted by researchers and scholars to investigate the servitization process [**20**]. Few authors directly addressed the definition of servitization [**7**,**8**,**21**]. Several authors identified a variety of forms of servitization [**8**], defining the "product-service continuum" [**9**,**22**,**23**], i.e. a continuum from traditional manufacturing companies to product-service providers able to manage all the product lifecycle and to offer complex solutions.

Opportunities and barriers for the implementation of the servitization process have been widely studied [**9**–**11**,**24**]. Oliva and Kallenberg [**25**] emphasized the role of services as a market entry barrier for competitors because of their difficulty to be imitated. A number of different motivations that may drive a manufacturing company to undertake a servitization path have been found and widely analysed: differentiation from competitors [**26**] and improve product reliability [**27**], customer loyalty [**28**] and product performance [**29**]. Moreover, services are usually more profitable than products for manufacturing companies [**30**]. In this regards, Fang et al. [**17**] examined data about 477 manufacturing firms and concluded that the service offering has a positive effect on the value

generated by a company when their weight on revenues is over 20-30%. Moreover, the effect of service sales on company revenues is related to firm and industry factors. Finally, the servitization process seems to produce better results when the service offering is related more to the firm core products.

However, a number of studies have shown that firms may also face barriers to implement the servitization process [**31**]. In this regards, Martinez et al. [**32**] identified five categories of challenges: (i) the need for a product-service culture for traditional manufacturing companies; (ii) the ability to manage the delivery of integrated offering through a plurality of touch-points; (iii) the acquisition of the internal processes and capabilities in order to compete in new service markets; (iv) the alignment of mindset and understanding towards service provision and (v) the ability to build new supplier relationships and to cooperate in innovative service ecosystems.

Previous studies analyzed the extent of servitization across different countries. In a widely acknowledged study, Neely and colleagues [**33**] analyzed the global trends of manufacturing servitization. Their paper compared the servitization extent in 27 countries. In 2014, Dachs et al. published a quantitative study based on the data contained in the European Manufacturing Survey and concluded that: (i) national differences in servitization play a minor role; (ii) firm size is relevant and (iii) the degree of servitization is not linearly dependent on the firm size, they found a U-shape distribution [**15**].

2.2 Product-related services and servitization

Servitized manufacturing companies provide complementary services to differentiate their products and promote their economic growth [**34**]. The scientific literature proposes a number of different classifications of such services [**35**,**36**]. Summarizing the different proposals, product-related services can be clustered in the following macro typologies [**37**]: (i) consultancy, (ii) design and development, (iii) retail and distribution, (iv) financial, (v) logistic, (vi) installation and setup, (vii) management and operating, (viii) maintenance and support, (ix) disposal and conversion. See Table 1 for a brief description of each category of service.

Depending on whether companies provide product-related services, they can be classified into three categories [**7**,**12**]:

(i) pure manufacturing companies, i.e. companies whose activities are limited to manufacturing;

(ii) servitized manufacturing companies, i.e. manufacturers that develop service offerings that support their products;

(iii) pure service companies, i.e. companies providing services only (previously being manufacturing companies).

Product-related service	Brief description
Consultancy	the manufacturing company shares his practical experience in the field to advise and assist customers.
Design and development	the company customizes the design and development of the product for third parties to meet the specific needs of their customers.
Retail and distribution	the manufacturing company directly promotes and distributes its products to the end customers, exports it to foreign countries and sells it. These services do not include those of the simple sale of goods produced without an articulated organization to support customer service.
Financial	the company directly manages long-term credits related to its products, deferring their payment or proposing rental or leasing contracts.
Logistic	the company provides delivery, transport and/or storage services for its or customer's products, components or raw materials.
Installation and setup	the company installs and tests its products, also training the personnel in charge of their use.
Management and operating	the company operates its products throughout their life cycle, the customer receives only the benefits of the use of the product without having to run it.
Maintenance and support	the company offers the necessary support services to solve potential operational problems during the life cycle of the product, offering spare parts and skilled labour capable of repairing or updating the product features. Possible support services are also those that allow the regular functioning of the product.
Disposal and conversion	at the end of the life cycle of the product, the manufacturing company deals with the demolition, conversion or recycling of the product materials.

Table 1. Classification and short description of product-related services. Adapted from Mastrogiacomo et al. [12,37]

2.3 Factors affecting the servitization process

The following sections will test the effect of commodity sector, company dimension and geographical location on servitization, observed from two different aspects:

- the *variety of services offered*, i.e. the number of different service typologies that a company provides and
- the *composition of service portfolio*, intended as the specific service typologies offered by a manufacturing companies.

The two aforementioned aspects will be tested against the following hypotheses (see Figure 1):

- *H1: Commodity sector*
  - *H1.a: Variety of services offered is associated with commodity sector*
  - *H1.b: Composition of service portfolio is associated with commodity sector*
- *H2: Company dimension*
  - *H2.a: Variety of services offered is associated with company dimension*
  - *H2.b: Composition of service portfolio is associated with company dimension*
- *H3: Company geographical location*
  - *H3.a: Variety of services offered is associated with geographical location*
  - *H3.b: Composition of service portfolio is associated with geographical location*

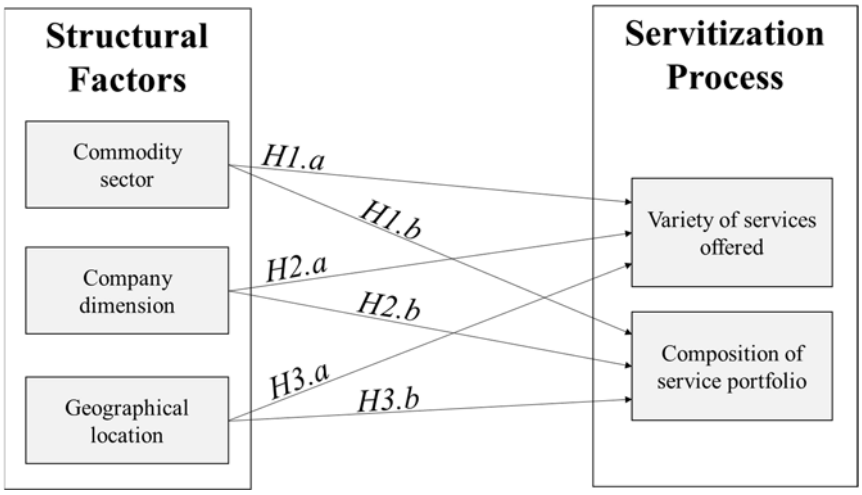

Figure 1. Factors influencing servitization in manufacturing companies.

3. METHODOLOGY

A quantitative analysis of secondary data was used to gain a detailed understanding of the factors that may affect servitization. This approach allowed to obtain and analyse information on a large number of companies of different sizes, geographical locations and commodity sectors.

Data used for the proposed analysis were retrieved in September 2018 from the ORBIS database which contains personal, commercial and financial data of about 275 million companies across the globe [**38**]. Only medium and large size companies were analysed in the study (number of employees higher than 50). Small companies were not considered due to the limited availability of information regarding their business activities. In this analysis, only manufacturing companies were considered, i.e. companies belonging to the NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) sectors classified with codes 10 to 32 [**39**]. For a comprehensive description of NACE sectors see Table 2.

The initial sample consisted of 190442 companies located in 124 countries around the world.

Among other information, the ORBIS database provides a textual overview of the main activities that each company carries out and a textual description of their trades. Thanks to the definition of a series of 10 different sets of keywords (one for each product-related service typology plus one for a "general service" category aimed at gathering any service activity which was not directly attributable to the other categories), this information has been processed according to the method proposed by Neely et al. [7] for discriminating between servitized and pure manufacturing companies. To define these keyword sets, the authors followed an iterative procedure, analysing a series of company overviews (100 per each iteration) randomly extracted from the initial sample of companies, manually selecting the keywords considered representative of the nine different typologies of product-related services. The iterative procedure was stopped when the iteration resulted in no further additions within the keyword lists. After a preliminary selection, the list of keywords was then extended with variants and synonyms to get the final set. For further details, we refer the reader to Appendix A that contains the complete list of keywords used for the analysis hereafter presented.

The keyword lists were used to analyze all the companies in the sample: each company was classified as servitized if characterized by a textual overview containing at least a keyword of the list. In addition, the clustering of the service keywords allowed a distinction between the typologies of services provided according to the classification proposed in Section 2.2.

NACE rev. 2 Code	Description
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing

Table 2. Detail of NACE rev. 2 sectors from 10 to 32 (European Community 2002).

4. EMPIRICAL RESULTS

The application of the described methodology provided a global picture of the process of servitization. From the original sample (190442 companies), only servitized companies were considered (72797 companies, i.e. 38% of the initial sample). This first exploration on the extent on servitization process lead us to a first finding:

Finding 1: 38% of the manufacturing companies are servitized. The remaining 62% are still focused on manufacturing activities only.

To test the hypotheses formulated in Section 2.4, data obtained from the ORBIS database were analyzed by testing one-factor-at-a-time, i.e. commodity sector, company dimension and geographical location.

4.1 Servitization vs. commodity sector

For each NACE sector, Table 3 reports the number of analyzed companies and their distribution per number of offered type of service.

NACE Sector	Number of companies	Variety of services offered					
		1	2	3	4	5	6
10	5447	87%	9%	4%	0%	0%	0%
11	575	86%	9%	4%	1%	0%	0%
12	51	86%	12%	0%	2%	0%	0%
13	1360	85%	11%	3%	0%	0%	0%
14	1655	85%	12%	2%	0%	0%	0%
15	661	87%	10%	2%	0%	0%	0%
16	1671	76%	18%	4%	1%	0%	0%
17	2158	81%	15%	3%	1%	0%	0%
18	3477	83%	12%	4%	1%	0%	0%
19	508	77%	16%	5%	2%	0%	0%
20	6098	87%	10%	3%	0%	0%	0%
21	2079	89%	8%	3%	0%	0%	0%
22	4563	81%	15%	3%	1%	0%	0%
23	2144	77%	17%	5%	1%	0%	0%
24	2263	82%	14%	4%	1%	0%	0%
25	8062	78%	16%	5%	1%	0%	0%
26	6689	72%	20%	7%	2%	0%	0%
27	4104	74%	18%	6%	1%	0%	0%
28	9361	72%	20%	7%	1%	0%	0%
29	3519	75%	20%	4%	0%	0%	0%
30	1941	54%	34%	9%	3%	1%	0%
31	1641	76%	18%	5%	1%	0%	0%
32	2770	74%	17%	7%	1%	0%	0%
ALL COMPANIES	**72797**	**78%**	**16%**	**5%**	**1%**	**0%**	**0%**

Table 3. Variety of services offered vs. NACE sector (Sample of 72797 manufacturing companies).

Considering all the commodity sectors, the great majority of servitized companies (78%) are still concentrated on the offering of a single service typology and only a minority offer more than three service typologies. Considering the variety of services offered, it is evident how different commodity sectors may have different tendencies to offer services. As an example, Figure 2 compares the

distribution of the variety of services offered in servitized companies operating in three different commodity sectors: NACE 10 (Manufacture of food products), NACE 26 (Manufacture of computer, electronic and optical products) and NACE 30 (Manufacture of other transport equipment). As we can see, differences in variety of services offered are significant.

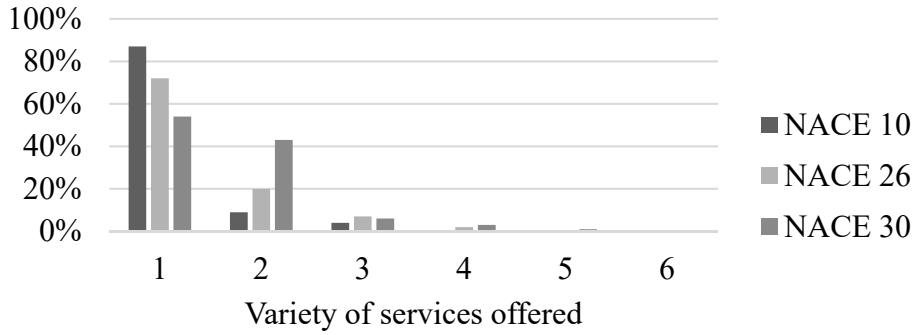

Figure 2. Variety of services offered in NACE 10 (Manufacture of food products), NACE 26 (Manufacture of computer, electronic and optical products) and NACE 30 (Manufacture of other transport equipment).

The Pearson chi-squared statistic was applied for testing the independence of the distribution the variety of services offered [**40**]:

$$\begin{cases} \textbf{null hypothesis: } Variety\ of\ services\ offered\ is\ not\ associated\ with\ commodity\ sector \\ \textbf{alternative hypothesis: } H1.a \end{cases}$$

According to data in Table 3, the observed chi-squared test statistic ($\chi^2 = \sum_{ij} \frac{(n_{ij}-\mu_{ij})^2}{\mu_{ij}}$, where n_{ij} is the observation and $\mu_{ij} = \left(\sum_{ij} n_{ij}\right) \frac{\sum_i n_{ij}}{(\sum_{ij} n_{ij})} \frac{\sum_j n_{ij}}{(\sum_{ij} n_{ij})}$ the expected value of a specific cell) is equal to *2307.1*, with a number of degrees of freedom (*df*) equal to *110* [**40**]. The chi-squared distribution has a mean of *df = 110*, and a standard deviation of $\sqrt{2df} = 14.83$. So, a value of *2307.1* is far out in the right-hand tail, being the P-value smaller than 10^{-5}. This evidence of association would be rather unusual if the variables were truly independent. With a significance level equal to 0.01, the null hypothesis can be rejected, leading to the following finding:

Finding 2: commodity sector and variety of services offered are associated

Moreover, different commodity sectors show dissimilar propensities toward the provision of different types of services. This tendency is evident in Table 4 that reports the percentage of servitized companies providing specific typologies of service.

NACE sector	Consultancy services	Design and development services	Financial services	Logistic services	Installation and setup services	Management and operating services	Maintenance and support services	Disposal and conversion services	Retail e distribution services	General services
10	7%	9%	8%	2%	2%	5%	12%	1%	44%	26%
11	10%	2%	13%	2%	3%	8%	17%	1%	45%	18%
12	12%	6%	6%	0%	2%	2%	12%	0%	71%	8%
13	8%	16%	10%	3%	6%	9%	21%	3%	27%	17%
14	5%	20%	5%	1%	3%	6%	11%	1%	49%	15%
15	4%	24%	4%	1%	11%	4%	13%	1%	47%	7%
16	17%	29%	8%	3%	11%	4%	24%	5%	17%	11%
17	8%	20%	7%	3%	6%	5%	19%	6%	31%	16%
18	9%	17%	8%	1%	4%	2%	23%	1%	16%	41%
19	12%	9%	9%	20%	6%	2%	25%	7%	21%	18%
20	10%	16%	5%	3%	4%	4%	44%	3%	17%	11%
21	8%	8%	6%	1%	2%	5%	32%	1%	36%	15%
22	9%	22%	5%	4%	7%	5%	37%	6%	14%	12%
23	11%	18%	10%	5%	14%	7%	30%	6%	14%	16%
24	12%	15%	8%	6%	10%	5%	26%	12%	8%	21%
25	10%	20%	5%	4%	15%	5%	32%	5%	12%	20%
26	15%	16%	8%	4%	13%	13%	40%	4%	12%	16%
27	14%	13%	5%	4%	16%	10%	39%	5%	16%	13%
28	12%	15%	6%	5%	17%	6%	44%	10%	7%	15%
29	11%	9%	9%	8%	6%	4%	53%	4%	13%	14%
30	10%	11%	8%	10%	11%	4%	72%	25%	4%	7%
31	9%	22%	7%	2%	17%	5%	23%	2%	37%	7%
32	12%	18%	10%	2%	13%	10%	32%	3%	23%	12%
ALL COMPANIES	**11%**	**16%**	**7%**	**4%**	**10%**	**6%**	**34%**	**5%**	**19%**	**17%**

Table 4. Composition of service portfolio per NACE sector.

Aggregating all manufacturing sectors, service typologies majorly offered are “maintenance and support” (34%) and “retail and distribution” (19%). However, the composition of service portfolio per production sector can be rather different. For example, 49% of NACE 14 companies (Manufacture of wearing apparel) offer retail and distribution services; this percentage drops to 4% if we consider NACE 30 (Manufacture of other transport equipment). As an example, Figure 3 compares the service portfolio of three different industrial sectors (NACE 10, 20, 29).

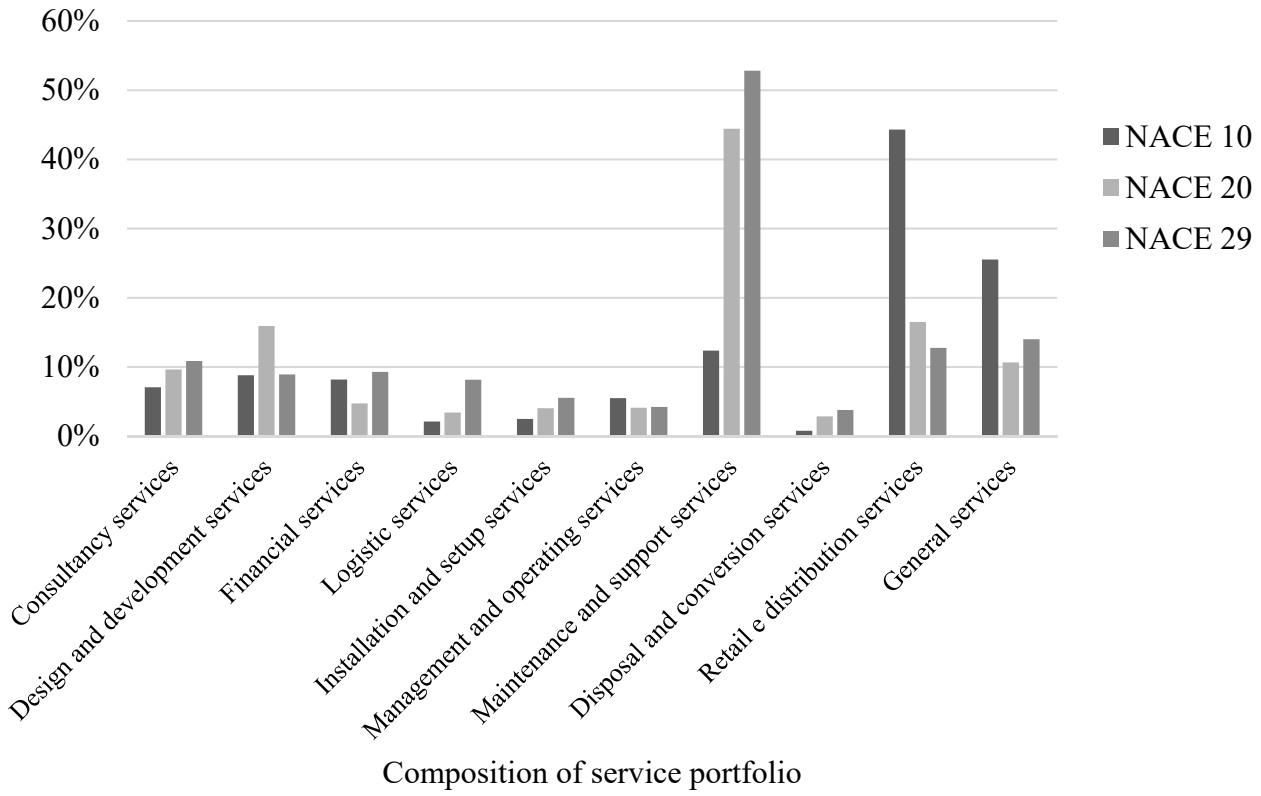

Figure 3. Composition of service portfolio in NACE 10 (Manufacture of food products), NACE 20 (Manufacture of chemicals and chemical products) and NACE 29 (Manufacture of motor vehicles, trailers and semi-trailers).

The hypotheses herein tested are:

$$\begin{cases} \textbf{null hypothesis: } Composition\ of\ service\ portfolio\ is\ not\ associated\ with\ commodity\ sector \\ \textbf{alternative hypothesis}: H1.b \end{cases}$$

The observed chi-squared test statistic is equal to *19909*, with *df = 198*. The chi-squared distribution has a mean of *df=198*, and a standard deviation of $\sqrt{2df} = 19.90$. In such a condition, the observed value is far out in the right-hand tail (the P-value is smaller than 10^{-5}). With a significance level equal to 0.01, the observations suggest rejecting the null hypothesis, so as to accept the alternative hypothesis:

Finding 3: Commodity sector and composition of service portfolio are associated

4.2 Servitization vs. company dimension

According to the dimension of a company in terms of employees, Table 5 shows the percentage of companies offering a specific number of service typologies (hereafter referred to as variety of services offered).

Dimension [employees]	Number of companies	Variety of services offered					
		1	2	3	4	5	6
>2500	3582	68%	21%	8%	3%	0%	0%
1500-2499	2285	70%	21%	7%	1%	0%	0%
1000-1499	2498	75%	18%	6%	1%	0%	0%
750-999	2911	79%	16%	4%	1%	0%	0%
500-749	3758	76%	17%	7%	1%	0%	0%
250-499	11422	79%	15%	4%	1%	0%	0%
150-249	16755	79%	16%	4%	1%	0%	0%
75-149	21778	79%	15%	4%	1%	0%	0%
50-74	7808	81%	14%	4%	0%	0%	0%
ALL COMPANIES	**72797**	**78%**	**16%**	**5%**	**1%**	**0%**	**0%**

Table 5. Variety of services offered vs. company dimension.

A preliminary examination of data contained in Tables 5 suggests that the number of employees could be a significant factor that influences servitization in terms of variety of services offered. In particular, the variety of services offered seems to be positively related to the dimension of the company. As we can see in Table 5, the larger the dimension, the higher the percentage of companies that offer more than one service typology.

A confirmation of this heterogeneity comes from the application of the Pearson Chi-squared test to verify the following hypotheses:

$$\begin{cases} \textbf{null hypothesis}: \ Variety\ of\ services\ offered\ is\ not\ associated\ with\ company\ dimension \\ \textbf{alternative hypothesis}: \ H2.a \end{cases}$$

The observed value is equal to 559.67, with a P-value smaller than 10^{-5} (in this case the observed value is checked against a chi-squared distribution with a mean of $df=40$, and a standard deviation of $\sqrt{2df} = 8.94$). With a significance level equal to 0.01, these evidences suggest the rejection of the null hypothesis:

Finding 4: dimension of manufacturing companies, in terms of number of employees, and variety of services offered are associated.

Table 6 reports the distribution of companies with respect to the specific typology of service offered. Again, companies are classified by size.

Dimension	Consultancy services	Design and development services	Financial services	Logistic services	Installation and setup services	Management and operating services	Maintenance and support services	Disposal and conversion services	Retail e distribution services	General services
>2500	15%	11%	15%	8%	11%	7%	37%	7%	21%	15%
1500-2499	15%	11%	12%	7%	11%	6%	36%	6%	21%	16%
1000-1499	15%	9%	10%	6%	11%	5%	36%	5%	21%	16%
750-999	13%	12%	7%	5%	9%	5%	35%	5%	20%	16%
500-749	15%	10%	8%	5%	11%	6%	36%	6%	21%	15%
250-499	11%	13%	7%	4%	10%	5%	36%	5%	20%	16%
150-249	9%	19%	6%	4%	10%	5%	33%	5%	19%	18%
75-149	9%	20%	6%	3%	10%	7%	33%	5%	17%	17%
50-74	10%	12%	6%	3%	10%	10%	34%	5%	16%	16%
ALL COMPANIES	**11%**	**16%**	**7%**	**4%**	**10%**	**6%**	**34%**	**5%**	**19%**	**17%**

Table 6. Distribution of service typologies per company dimension.

In this case, data in the Table 6 does not show any obvious difference in behaviour between companies of different sizes. For example, some service typologies, such as "Installation and setup" or "Disposal and conversion", present similar percentages in all the nine classes of analysis. However, applying the Pearson Chi-squared test, a statistical relevance of the size factor of the company can be evidenced. In detail, data in Table 6 were used to test the following hypotheses:

$$\begin{cases} \textbf{null hypothesis}: \ Composition\ of\ service\ portfolio\ is\ not\ associated\ with\ company\ dimension \\ \textbf{alternative hypothesis}: H2.b \end{cases}$$

The observed value is equal to *2367.6*, with a P-value smaller than 10^{-5} (in this case the reference chi-squared distribution has a mean of *df=72*, and a standard deviation of $\sqrt{2df} = 12$). With a significance level equal to 0.01, the null hypothesis is rejected:

Finding 5: dimension of manufacturing companies, in terms of number of employees, and composition of service portfolio are associated.

4.3 Servitization vs. company geographical location

The last factor herein considered is the geographical location of the servitized manufacturing companies. According to hypothesis *H3*, this factor could be related to the servitization process. To test this hypothesis data referred to variety of services offered, and service portfolio composition were analyzed taking into account the location of company headquarters. Table 7 shows the distribution of the variety of services offered depending on the country. Only countries with more than 500 companies in the sample were analysed.

Country	Number of companies	Variety of services offered					
		1	2	3	4	5	6
Australia	844	68%	20%	9%	2%	0%	0%
Brazil	1694	86%	12%	2%	0%	0%	0%
Canada	1472	77%	17%	5%	1%	0%	0%
China	13156	79%	15%	4%	1%	0%	0%
Czech Republic	1206	79%	15%	5%	1%	0%	0%
France	1615	82%	14%	4%	1%	0%	0%
Germany	5987	79%	15%	4%	1%	0%	0%
Hong Kong	1233	85%	11%	4%	1%	0%	0%
Italy	2787	81%	14%	4%	1%	0%	0%
Japan	5709	83%	14%	3%	0%	0%	0%
Mexico	1065	86%	11%	3%	0%	0%	0%
Netherlands	624	73%	18%	8%	1%	0%	0%
Poland	544	82%	16%	2%	0%	0%	0%
Republic of Korea	1354	84%	13%	3%	0%	0%	0%
Romania	532	81%	14%	5%	0%	0%	0%
Russian Federation	2350	82%	14%	4%	1%	0%	0%
Spain	1322	82%	13%	4%	1%	0%	0%
Sweden	552	79%	16%	4%	1%	0%	0%
Switzerland	673	74%	15%	9%	2%	0%	0%
United Kingdom	4379	66%	22%	10%	2%	0%	0%
United States of America	14205	74%	19%	5%	1%	0%	0%
ALL COMPANIES	**72797**	**78%**	**16%**	**5%**	**1%**	**0%**	**0%**

Table 7. Variety of services offered vs. geographical location. Only country with a sample of at least 500 companies are reported.

Also in this case, the relation between variety of services offered and company location is evident from a qualitative analysis of the data. For example, the behaviour of manufacturing companies in the United Kingdom and Brazil seems to be radically different. This evidence is confirmed by the Pearson Chi-squared test. Data reported in Table 7 were used to test the two following hypotheses:

$$\begin{cases} \textbf{null hypothesis}: \ Variety\ of\ services\ offered\ is\ not\ associated\ with\ geographical\ location \\ \textbf{alternative hypothesis}: \ H3.a \end{cases}$$

The observed value is equal to *1215.9*, with a P-value smaller than 10^{-5} (the observed value is checked against a chi-squared distribution with a mean of $df = 100$, and a standard deviation of $\sqrt{2df} = 14.14$). With a significance level equal to 0.01, this evidence suggests rejecting the null hypothesis, leading to the following consideration:

Finding 6: geographical location of manufacturing companies and variety of services offered are associated.

Table 8 shows composition of service portfolio depending on geographical location.

Country	Consultancy services	Design and development services	Financial services	Logistic services	Installation and setup services	Management and operating services	Maintenance and support services	Disposal and conversion services	Retail e distribution services	General services
Australia	11%	17%	22%	3%	14%	7%	34%	5%	20%	14%
United Kingdom	12%	12%	20%	3%	14%	9%	36%	8%	22%	15%
Czech Republic	12%	16%	5%	5%	12%	8%	29%	5%	13%	23%
Germany	13%	14%	6%	4%	13%	10%	30%	6%	12%	20%
Sweden	12%	16%	7%	6%	9%	7%	29%	5%	15%	20%
Italy	13%	15%	4%	4%	10%	7%	32%	5%	17%	16%
Spain	10%	13%	4%	3%	12%	10%	29%	5%	17%	19%
France	8%	14%	12%	4%	10%	5%	29%	5%	16%	20%
Netherlands	10%	12%	16%	3%	10%	14%	34%	5%	15%	18%
Switzerland	14%	15%	11%	4%	13%	15%	36%	4%	9%	17%
Japan	8%	8%	9%	5%	8%	9%	40%	5%	14%	14%
Republic of Korea	6%	9%	9%	3%	6%	9%	35%	4%	20%	18%
China	19%	8%	5%	5%	10%	4%	42%	3%	21%	11%
Brazil	5%	14%	3%	3%	8%	6%	35%	6%	20%	19%
Romania	6%	14%	3%	4%	9%	7%	36%	6%	23%	16%
Russian Federation	5%	11%	4%	4%	12%	6%	38%	7%	19%	16%
Mexico	7%	15%	3%	6%	7%	3%	32%	4%	21%	18%
Poland	5%	17%	3%	3%	12%	3%	31%	6%	18%	22%
Hong Kong	8%	16%	5%	2%	6%	11%	21%	3%	27%	21%
Canada	8%	29%	4%	4%	8%	3%	29%	6%	22%	19%
United States of America	6%	32%	5%	5%	9%	3%	31%	6%	19%	17%
ALL COMPANIES	**11%**	**16%**	**7%**	**4%**	**10%**	**6%**	**34%**	**5%**	**19%**	**17%**

Table 8. Composition of service portfolio vs. geographical location. Only countries with a sample of at least 500 companies are reported.

The geographical location of the company seems to be also related to composition of service portfolio. For instance, a significant difference can be noticed in the case of development services that are provided by 32% and 8% of U.S. and Asian companies. Data reported in Table 8 were used to test the following hypotheses:

$$\begin{cases} \textbf{null hypothesis}: \ Composition\ of\ service\ portfolio\ is\ not\ associated\ with\ geographical\ location \\ \textbf{alternative hypothesis}: \ H3.b \end{cases}$$

The observed chi-squared test statistic is equal to *9534.1*, with $df = 180$. The chi-squared distribution has a mean of *df=180*, and a standard deviation of $\sqrt{2df} = 18.97$. The P-value related to the observation is smaller than 10^{-5}. This result leads to the rejection of the null hypothesis with a significance level equal to 0.01:

Finding 7: geographical location and composition of service portfolio are associated

In order to deepen this last result, countries were also clustered on the basis of data in Table 8. If choosing a dissimilarity threshold equal to 0.66, five main clusters emerge from the analysis of the dendrogram representing the Euclidean distance between distribution related to the 21 countries considered (see Figure 4). Similarities can be identified between countries belonging to the identified clusters: (i) the first cluster contains Australia and United Kingdom only. A high percentage of manufacturing companies in these two countries tend to offer financial services (around 20%); (ii) the second cluster includes European countries only; (iii) the third cluster is composed of Japan and Republic of Korea, two of the major economic powers in Asia; (iv) all countries composing the fourth cluster are categorized as emerging markets according to the International Monetary Fund [**41**]; (v) the fifth cluster is composed of North American countries (Canada and United States of America). China and Hong Kong have a dissimilar behaviour with respect to the identified clusters.

The homogeneity of the results between countries with similarities in terms of culture, development or location may be seen as a further evidence that the servitization process is also influenced by the geographical location of the company.

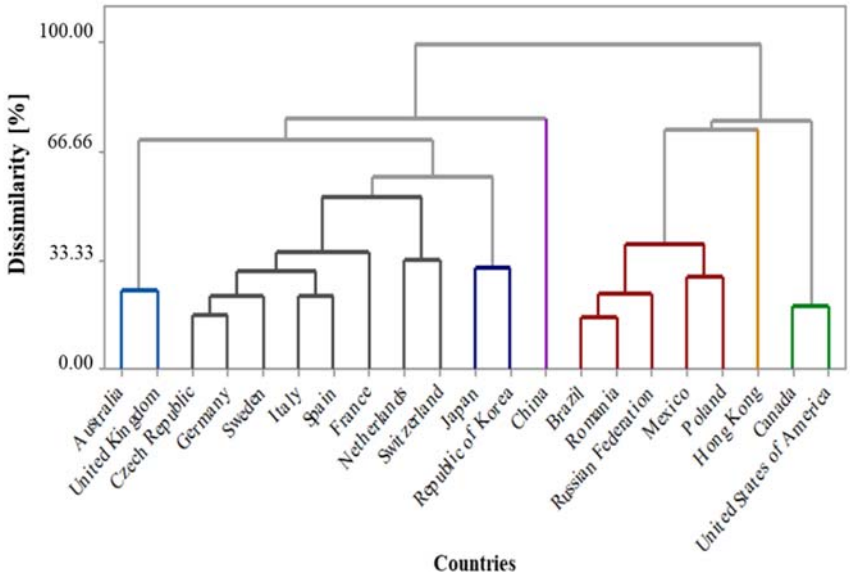

Figure 4. Dendrogram of the Euclidean distance between countries considering the composition of service portfolio

5. COMPANY POSITIONING

Data proposed in the previous sections show how structural factors affect servitization and specific tendencies in the assortment of provided services. Operatively, this analysis can be made more specific by focusing on a single company. Borrowing the concepts of cumulative distribution and its

complementary function from descriptive statistics, this section proposes and exemplifies the use of two indicators to map the company in its competitive scenario.

A comparison is possible if considering a specific company and the set of reference companies. For this purpose, the following notation is introduced:

- l is the number of service typologies delivered by the company in analysis and
- A_i the set of companies that exactly offer i typologies of service.

The first indicator is the *Higher Servitization Index* (*HSI*), defined as the proportion of companies that provide a number of service typologies greater than l:

$$HSI(l) = \frac{\sum_{i>l} |A_i|}{\sum_{\forall i} |A_i|} \quad (1)$$

Where the symbol "$|\cdot|$" denotes the cardinality operator, the *Lower Servitization Index* (*LSI*) is the proportion of competing companies offering a lower number of service typologies:

$$LSI(l) = \frac{\sum_{i<l} |A_i|}{\sum_{\forall i} |A_i|} \quad (2)$$

By definition, the two indicators are defined on the codomain $[0,1[$. A high value of *HSI* indicates that analyzed company is competing with relatively highly servitized companies. On the contrary, a high value of *LSI* denotes that the company is more servitized than its competitors.

Different options are possible in the selection of the reference set to calculate these indicators: the commodity sector, companies in a specific country or geographic area, the specific subset of direct competitor companies, etc. If considering the first option, data provided in Section 3 could be useful.

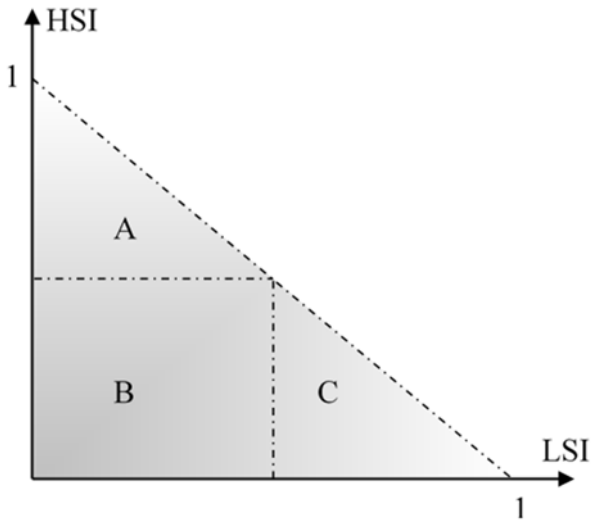

Figure 5. HSI versus LSI: a map for analyzing the positioning of a company with respect to the relevant competitors and positioning of the two companies exemplified in Table 9.

The positioning of a company on the map depends on the service offering of the company and the relevant competitors. With reference to Figure 5, three different zones can be qualitatively identified on the map:

- Zone A. Companies in this area belong to a sector in which many companies provide more service typologies and, conversely, few companies that offer a limited variety of service typologies. These companies can be said to be outside the general trend of the sector.
- Zone B. Companies that plot in this area belong to a sector that is centralized on a single attitude of service supply. These companies are in the mainstream of the servitization process.
- Zone C. Companies positioned in this zone can be distinguished by the higher offer of service typologies compared to the competitors.

To date, there is no general evidence of a direct relationship between the variety of provided service typologies and a company's success, e.g. in terms of revenues. Each company has its own specificity that should be adequately studied, for example (but not exclusively) by combining the aforementioned analysis of positioning with an indication regarding companies' profitability, for example in terms of return on investments (ROI). In this view, the proposed analysis constitutes a complementary element to be integrated into a comprehensive analysis.

6. CONCLUSIONS

The aim of the present research was to quantitively investigate the relationship between three structural factors and the servitization in manufacturing companies in terms of type and variety of offered services. The analysis of the service offering of a sample of 190442 (of which 72797 servitized) companies located in 124 countries showed that the servitization process is related three structural factors: commodity sector, company dimension and geographical location. To the best knowledge of the authors, this study is one of the first empirical attempts to identify specific behaviors of different commodity sectors, company size and geographical location, in terms of variety and typologies of services offered. In this sense, a comprehensive and novel facet of the servitization phenomenon is provided.

The causes of the disparities between sectors are not herein considered neither investigated, and surely deserve further analysis for which the outcomes of this study can lay the foundations. Future developments of this study will deal with the identification of the main causes of the highlighted disparities.

Also, two indicators are introduced for the evaluation of the strategic positioning of a company within its competitive scenario. The authors believe these indicators would be useful to provide a quantitative view of a company's positioning in the servitization journey so as to guide future strategies.

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APPENDIX A

Service keywords				
Consultancy services Keywords	**Design and development services Keywords**	**Financial services Keywords**	**Logistic services Keywords**	**Installation and setup services Keywords**
consult	custom	financial	transportation	installation
consultancy	co-develop	leasing	trucking	implementation
consulting	personaliz*	hiring	consignment	procurement
planning	customiz*	hire	logistic	training
certification	personal design	financing	storage	test activities
	personal develop	loans		
	custom-built	insurance		
	engineering services			
Management and operating services Keywords	**Maintenance and support services Keywords**	**Disposal and conversion services Keywords**	**Retail e distribution services Keywords**	**General services Keywords**
supervision	repair	demolition	retail	service
life-cycle management	maintenance	conversion	marketing	services
conduction	support	dismission	promotion	
manages and operates	servicing	recycling	store	
	aftermarket	upgrades		
	spare part	modernization		
	technical service			
	inspection			
	optimization service			
	restoration			

Table A.1 Keyword list used for the segmentation among service typologies. Symbol "*" indicates any possible character(s). Being automated and dependent on the keyword choice, the authors are aware that lexicographical analysis can produce false results. For this reason, a manual post-processing refining of the result has been performed too.